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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

TANK INVESTIGATION OF THE GRUMMAN JRF-5 AIRPLANE EQUIPPED WITH TWIN HYDRO-SKIS

TED NO. NACA DE 357

By John A. Ramsen and George R. Gray

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

A tank investigation has been conducted on a $\frac{1}{8}$-size powered dynamic model of the Grumman JRF-5 airplane equipped with twin hydro-skis. The results of tests using two types of skis are presented: one had vertical sides joining the top surface to the chine; the other had the top surface faired to the chine to eliminate the vertical sides. Both configurations had satisfactory longitudinal stability although the model had a slightly greater stable elevator range available when the skis without the vertical sides were attached. Free model tests indicated no instability present when one ski emerged before the other. Considerable excess thrust was available at all speeds with either type of skis. A hump gross load-resistance ratio of 3.37 was obtained with the skis with the vertical sides and 3.53 with the other skis. Landing behavior in smooth water with yaw up to 15° and roll up to 15° in opposite directions was satisfactory with either type of skis.

INTRODUCTION

The results of NACA tank tests and full-scale trials by the Edo Corporation of a Grumman JRF-5 amphibian with an experimental hydro-ski landing gear for operation on water, snow, and ice are given in references 1 and 2. The results of tank tests of a similar gear for water operation alone are presented in reference 3. At the request of the

Bureau of Aeronautics, Department of the Navy, a further investigation has been made in Langley tank no. 2 of an alternate arrangement for water operation developed by Edo using twin hydro-skis in place of the single main hydro-ski.

The size of the twin skis was such that the ratio of gross weight to total ski area was approximately the same as for the single ski. Two types of skis were evaluated. The first was geometrically similar to the single ski. The second had the same length-beam ratio but was shallower in depth so that the vertical sides above the chines were eliminated and had slight changes in plan form.

Preliminary tests indicated that the best location and angular setting were the same for both types of twin skis. This paper presents the comparative results obtained with the final configuration chosen on the basis of the preliminary tests and other requirements of the design.

DESCRIPTION OF MODEL

The model was the $\frac{1}{8}$-size powered dynamic model used in the tests described in references 1 and 3. The general arrangement with the final twin-ski configuration is shown in figure 1. Photographs of the model are shown in figure 2.

The skis shown on these two figures have vertical sides connecting the top surface to the chine and are similar to the skis used in references 1 and 3. Their lines are shown by the solid lines in figure 3. The dashed lines on this figure show the lines of the second type of skis which had their top surfaces refaired to the chine to eliminate the vertical sides. The other changes incorporated in this second type of ski include sharpening of the plan form at both the bow and the stern and reducing the bow height. For identification purposes the skis with the vertical sides will be designated as type A and the others as type B.

APPARATUS AND PROCEDURE

Take-Off Tests

The tank setup with the model floating at normal gross weight (8000 lbs, full size) is shown in figure 4. The model was free to trim about the center of gravity and free to rise but was restrained laterally and in roll and yaw. Trim is defined as the angle between the undisturbed water surface and the forebody keel.

The elevators were varied over a range of deflections from -30° to 10°. A flap deflection of 30° was used for all the tests.

The longitudinal stability and the resistance were determined by the methods described in reference 1. Full power (3750 lbs thrust, full size) was used for the stability tests. Partial power corresponding to 62.5-percent static thrust (2340 lbs thrust, full size) was used for the resistance tests to correspond to that used in the tests described in references 1 and 3.

Some powered free-model tests were also made to investigate possible instability due to emergence of one ski before the other. For these tests the model was completely free from the towing carriage and the thrust was adjusted during the run so that it balanced the resistance. Tests were run both at constant speeds and with acceleration through the range of speeds near ski emergence.

Landing Tests

Landing tests were made with the model balanced about the normal center of gravity ($0.226\bar{c}$ where $\bar{c}$ is the mean aerodynamic chord) and the elevators set to maintain the desired trim while in the air. The model was launched from the Langley tank no. 2 monorail as a free body at a trim of 8° with no power. The behavior was recorded by means of motion pictures and visual observations.

The landing conditions investigated are given in the following table:

Landing condition	Roll (deg)	Yaw (deg)
1	0	0
2	15 left	0
3	0	15 left
4	15 left	15 left
5	15 right	15 left

For comparison similar tests were run with the single main ski used in the tests of references 1 and 3 but without the tail ski or wing-tip skids.

RESULTS AND DISCUSSION

Take-Off Tests

General behavior.- Sequence photographs of a typical take-off run with the type A skis are shown in figure 5. The model rose onto the skis between 20 and 30 miles per hour (full size) with either type of skis.

Spray in the propellers did not seem to be a problem. The roach aft of and between the skis had an effect in that the afterbody rested on this roach at the lower speeds in the planing range so that the trim was reduced.

Emergence instability (resubmergence of the skis after breaking the water surface) was present for the tests with either type of skis at an acceleration of 1.0 foot per second per second. This instability was overcome by increasing the acceleration to 2.5 feet per second per second with the type A skis and to 2.0 feet per second per second with the type B skis. These accelerations are readily attainable with the thrust available.

Results of the free-model tests indicated that no ill effects would be suffered if one ski emerged before the other. The second ski emerged almost immediately and the model righted itself with no tendency to become unstable. Despite the inherent difficulties associated with this type of test in a narrow tank, it was quite possible to maintain the model on a straight path through the speed of emergence.

Longitudinal stability.- The trim limits of stability are shown in figure 6 which also shows the extent of the emergence instability encountered at constant speeds. The lower limits below which porpoising was encountered were the same for the two types of skis except for a short speed range just after emergence when porpoising occurred at slightly higher trims with type B skis than with type A skis. No upper limit was encountered with either type of skis. There was no difference in the extent of the emergence instability encountered with the two types of skis.

Trim tracks for various elevator settings at the normal center of gravity are shown in figure 7. For the same elevator setting trims with the type A skis were higher than with the type B skis for the speeds up to emergence, lower for the speeds just after emergence, and the same for the higher speeds in the planing range.

The center-of-gravity limits of stability are presented in figure 8. Since the tests from which these limits were determined were run at an

acceleration of 1 foot per second per second, emergence instability occurred at all elevator settings and center-of-gravity locations but was not considered in plotting the limits shown in figure 8. The limits shown indicate the elevator deflections below which lower-limit porpoising would occur. No upper limit was encountered for any combination of center-of-gravity locations and elevator deflections. For all center-of-gravity locations aft of about 0.200$\bar{c}$, the model with type B skis had a stable range of elevator deflection 2.5° greater than the model with type A skis. Forward of about 0.200$\bar{c}$ the maximum available elevator deflection was reached without any stable elevator position being found with the type A skis. Forward of about 0.165$\bar{c}$ this same condition existed with the type B skis.

Resistance.- Curves of total resistance and the corresponding trim and rise are presented in figure 9. The total resistance includes both the water resistance and the air drag of the complete model and is the envelope of minimum resistance obtained from fixed trim tests over the stable range of trims. A curve showing the estimated available thrust is included in the figure. It can be seen that there is considerable excess thrust available at all speeds.

Both the resistance and corresponding trim are lower until just after emergence for the model with the type B skis. The difference, however, is rather small and no difference at all was discernible for the corresponding rise. The gross load-resistance ratio at the hump was approximately 3.37 with the type A skis and 3.53 with the type B skis.

The hump load-resistance ratio for the tandem-skis configuration of reference 1 which also included wing-tip skids was 3.14. Reference 3 showed an increase to 3.48 when the tail ski was replaced by an afterbody extension and a further increase to 3.62 by removing the wing-tip skids.

Landing Tests

Sequence photographs of a typical smooth-water landing with no power at 8° trim and with no roll or yaw for the model with the type B skis is shown in figure 10. The model planed on the skis while holding a nearly constant trim for the main part of the run. Just before submergence the trim increased until the aft end of the model contacted the water. The model then trimmed down, the skis submerged, and the model came to rest on the hull. The behavior was the same with the type A skis.

For the landing tests with yaw and roll, the behavior was essentially the same with either type of skis. The twin-ski

configuration possessed inherent stability in roll so that the model quickly corrected itself in roll regardless of the yaw angle present. It also corrected itself in yaw in the sense that it did not proceed down the tank in a yawed position. The straight path assumed, however, was usually at an angle to the path on which it was launched, that is, at some angle to the sides of the tank between zero and the initial angle of yaw.

Even with 15° left yaw and 15° right roll, no behavior was apparent which could not be readily controlled by a pilot. The model simply corrected itself in roll and yaw and proceeded on a straight and level path until the skis submerged.

When similar tests were attempted with the single main ski, the model behaved fairly well with yaw and no roll. The introduction of roll, however, caused a decided instability. The model showed no tendency to right itself in roll but yawed heavily in the direction of the roll so that quick submergence of the ski usually occurred.

CONCLUSIONS

A tank investigation on a $\frac{1}{8}$- size powered dynamic model equipped with twin hydro-skis indicated the following conclusions:

1. The model possessed adequate longitudinal stability with either type of twin skis but had about 2.5° more stable elevator range available with the skis without the vertical sides. No upper limit was present for the range of elevator settings and center-of-gravity locations tested. No instability was present when one ski emerged before the other.

2. There was little choice between the two types of skis as far as resistance was concerned. A hump gross load-resistance ratio of 3.37 was obtained with the skis with the vertical sides and 3.53 with the skis without the vertical sides. Considerable excess thrust was available at all speeds with either type of ski.

3. Landing behavior in smooth water was essentially the same with either type of skis and was very satisfactory. Roll of 15° and yaw of 15° in opposite directions did not have any serious effects on landing behavior.

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REFERENCES

1. Wadlin, Kenneth L., and Ramsen, John A.: Tank Investigation of the Grumman JRF-5 Airplane Fitted with Hydro-Skis Suitable for Operation on Water, Snow, and Ice. NACA RM L9K29, 1950.

2. Anon.: Summary Report on USAF Project MX-940. Rep. 2719, Edo Corp., April 5, 1949.

3. Ramsen, John A., and Gray, George R.: Tank Investigation of the Grumman JRF-5 Airplane with a Single Hydro-Ski and an Extended Afterbody. NACA RM L51E21, 1951.

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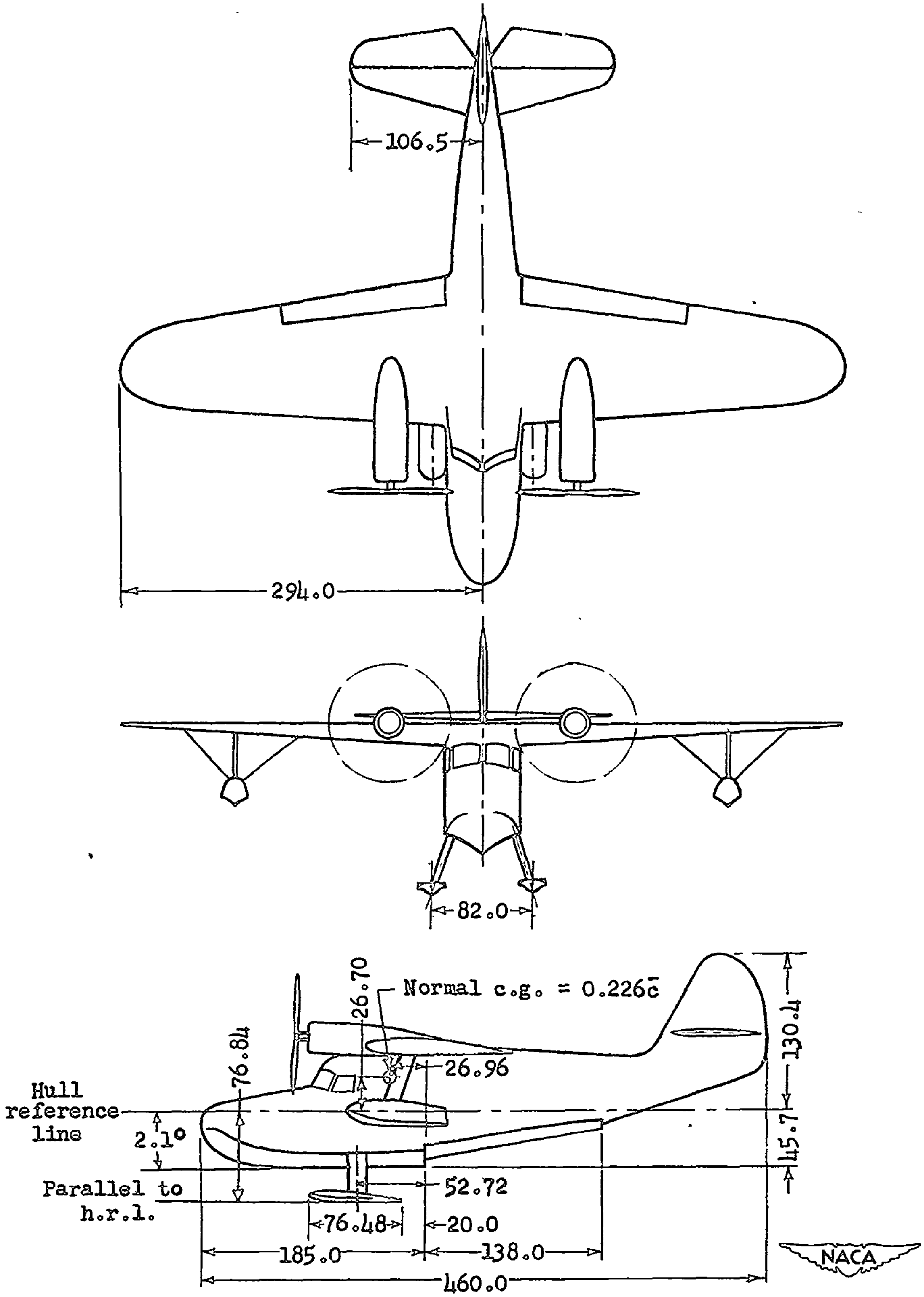
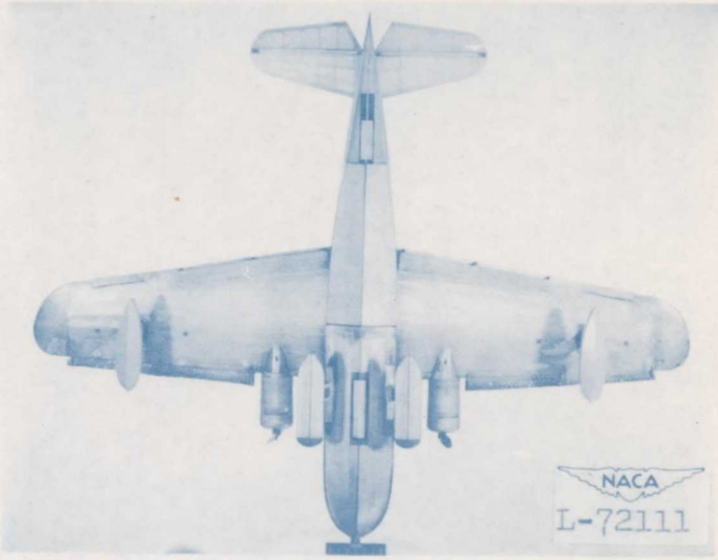


Figure 1.- General arrangement of $\frac{1}{8}$-size model of Grumman JRF-5 fitted with twin hydro-skis. (Dimensions are in inches, full size.)

[redacted]



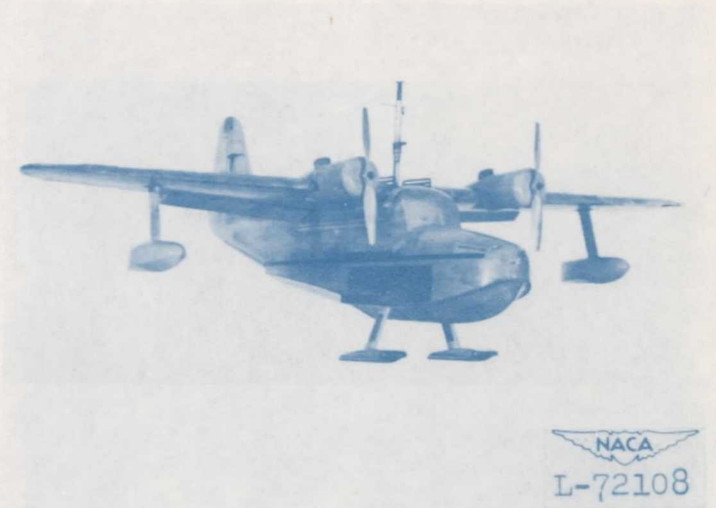


Figure 2.- Photographs of $\frac{1}{8}$ -size model of Grumman JRF-5 with twin hydro-skis.

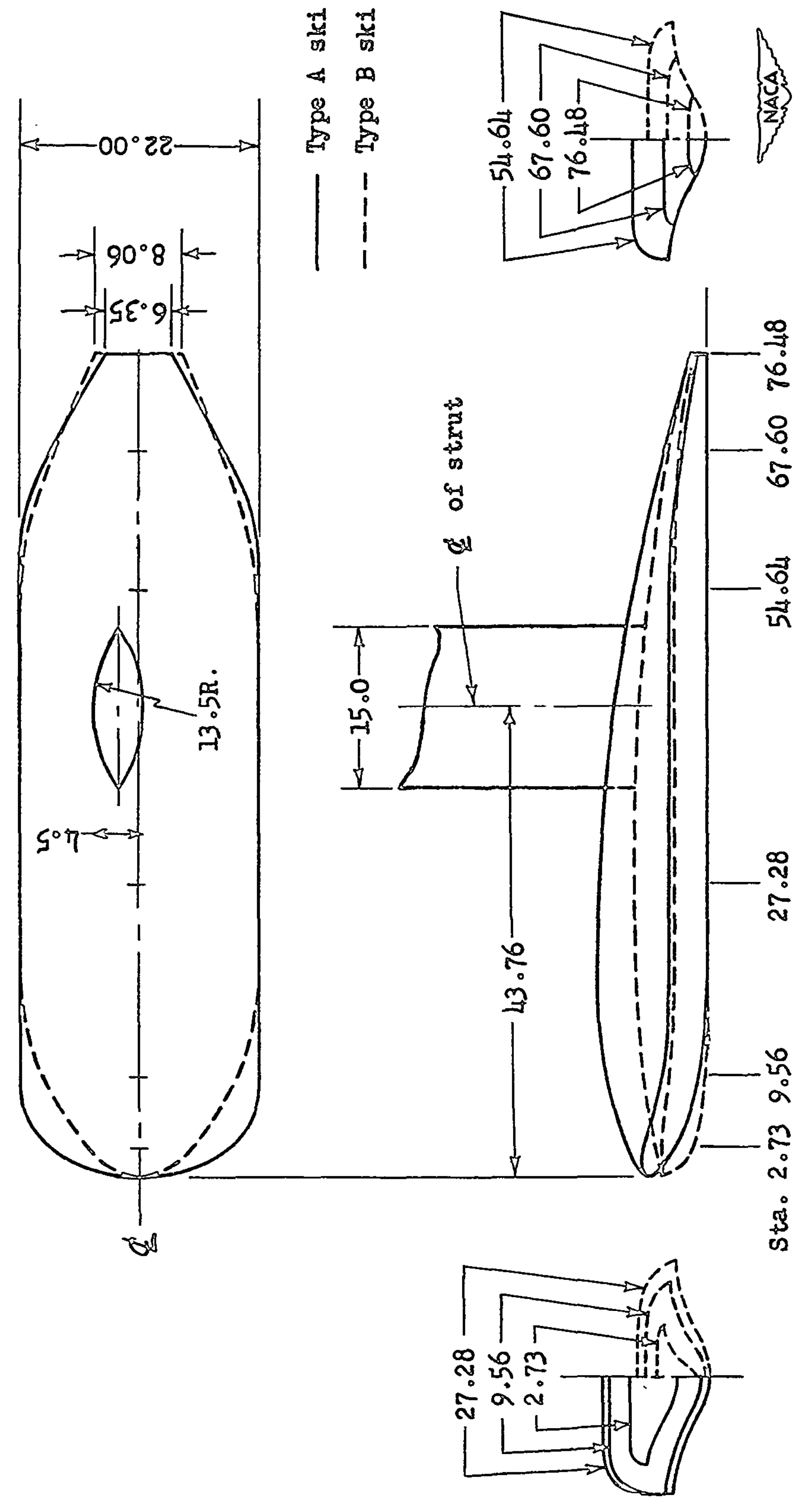


Figure 3.- Lines of twin hydro-skis. (Dimensions are in inches, full size.)

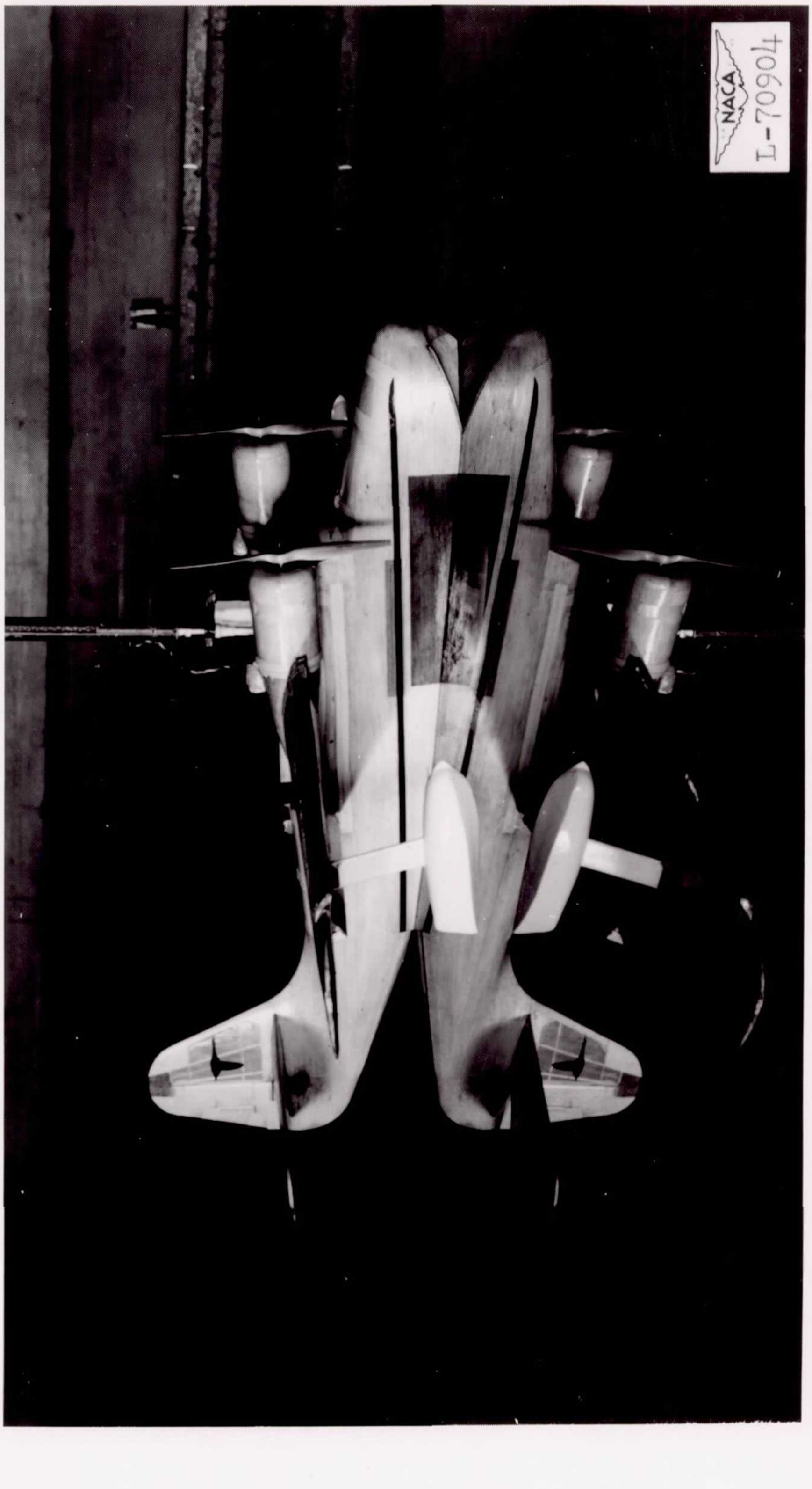
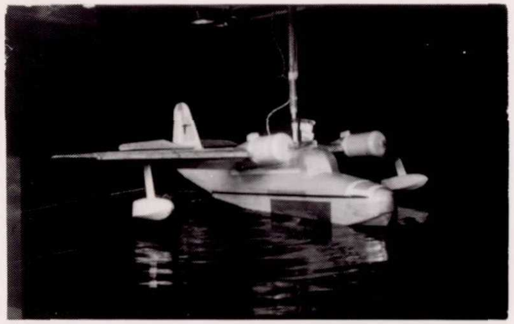
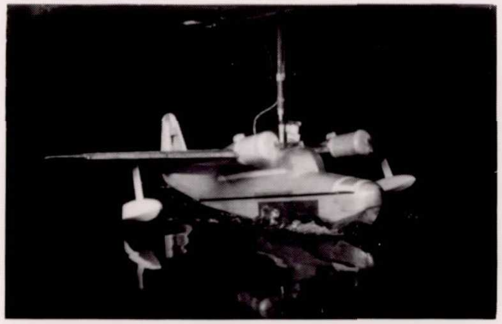


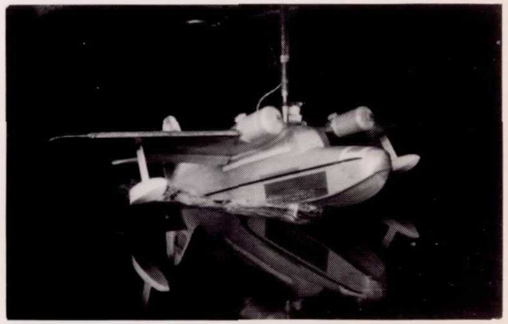
Figure 4.- Test setup showing model floating at normal gross weight.



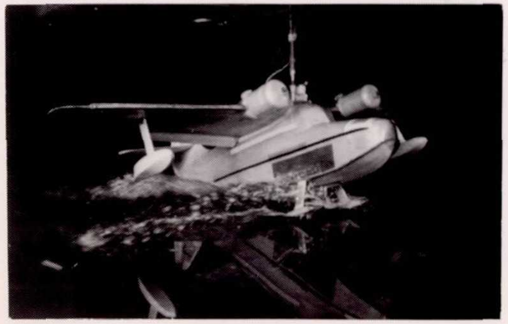
At rest



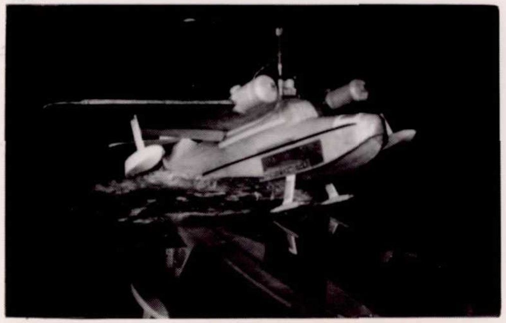
10 mph



20 mph



30 mph



50 mph

60 mph

Figure 5.- Sequence photographs of a typical take-off run for the Grumman JRF-5 with twin hydro-skis. (Values are full size.)

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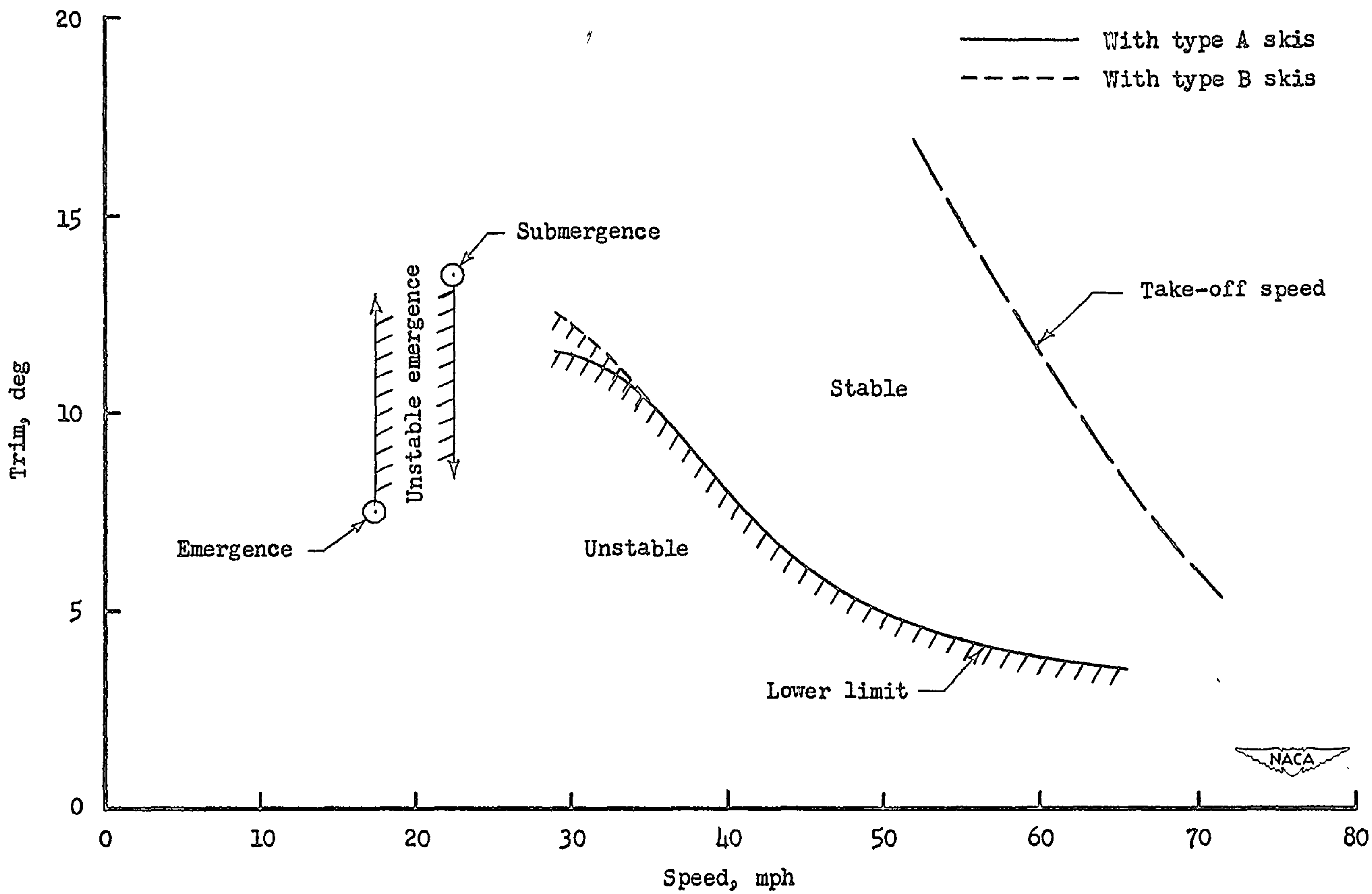
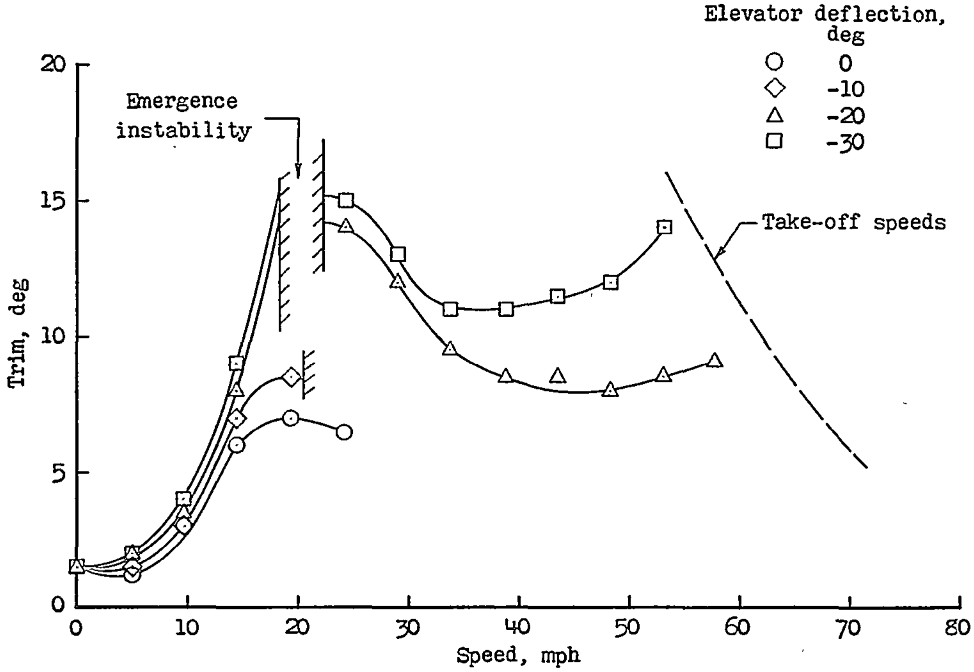
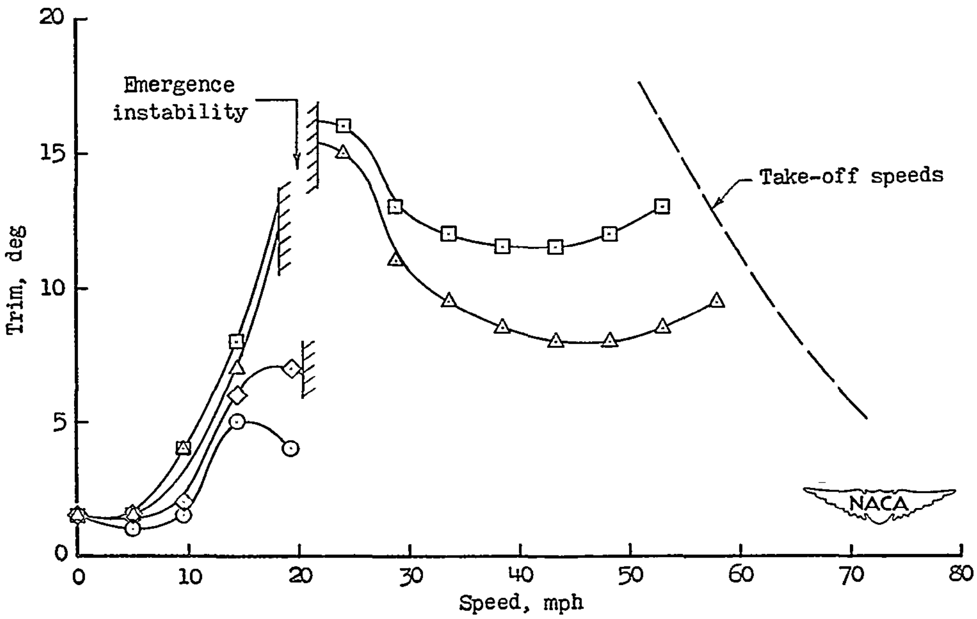


Figure 6.- Trim limits of stability for the Grumman JRF-5 with twin hydro-skis. (Values are full size.)



(a) With type A skis.



(b) With type B skis.

Figure 7.- Variation of trim with speed for the Grumman JRF-5 with twin hydro-skis. (Values are full size.)

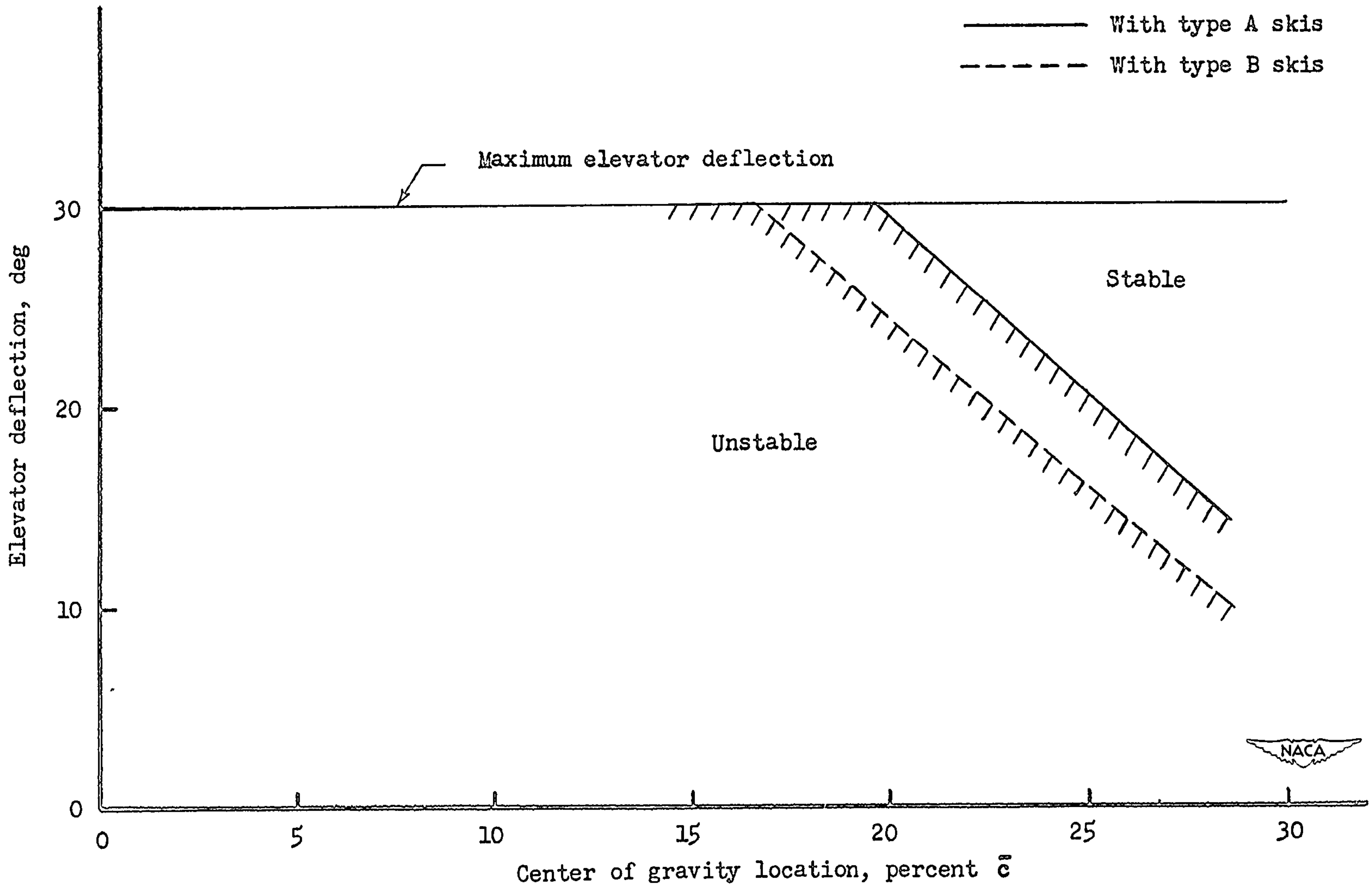


Figure 8.- Center-of-gravity limits of stability for the Grumman JRF-5 with twin hydro-skis.

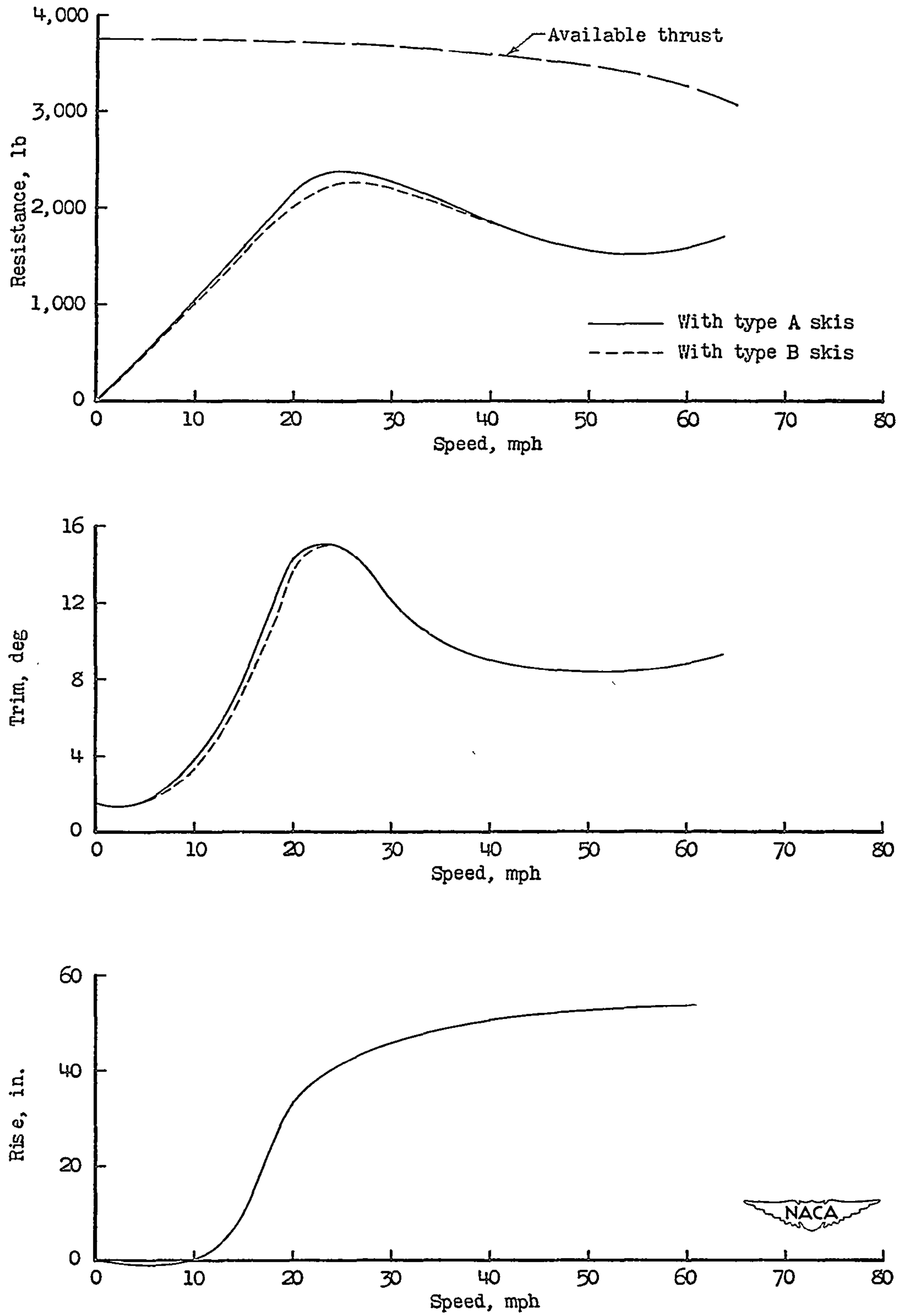
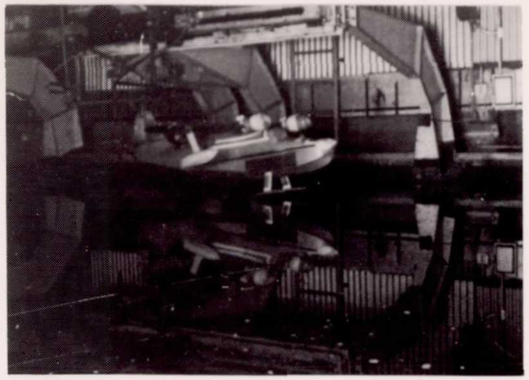
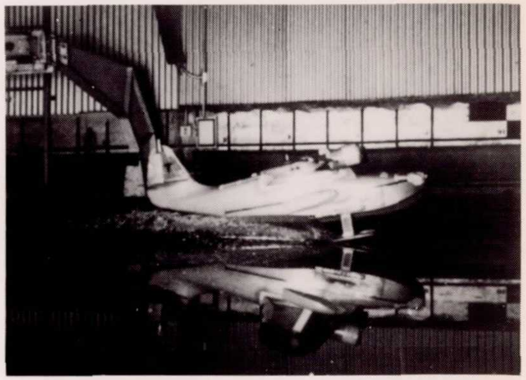


Figure 9.- Resistance, trim, and rise for the Grumman JRF-5 with twin hydro-skis. (Values are full size.)



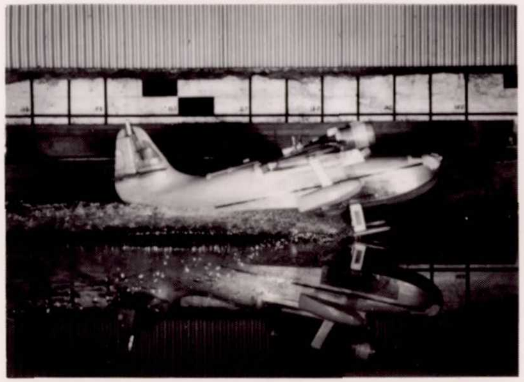
In flight

Just after contact



50 feet after contact

200 feet after contact



400 feet after contact

600 feet after contact

Figure 10.- Sequence photographs of a typical landing run in smooth water at 8° landing trim. (Distances are full size.)

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